Current Exoplanet Distribution

Ansgar Reiners
IAG
Exoplanet detections

today’s exoplanet.eu count is 998
The unseen companion of HD114762: a probable brown dwarf

David W. Latham*, Tsevi Mazeh†, Robert P. Stefanik*, Michel Mayor‡ & Gilbert Burki‡

* Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138, USA
† School of Physics and Astronomy, Raymond and Beverly Sackler Faculty of Exact Science, Tel Aviv University, Tel Aviv 69978, Israel
‡ Observatoire de Genève, Chemin des Maillettes 51, Ch-1290 Sauverny, Switzerland

Brown dwarfs are substellar objects with too little mass to ignite hydrogen in their cores. Despite considerable effort to detect brown dwarfs astrometrically1–4, photometrically4–9, and spectroscopically10–12, only a few good candidates have been discovered. Here we present spectroscopic evidence for a probable brown-dwarf companion to the solar-type star HD114762. This star undergoes periodic variations in radial velocity which we attribute to orbital motion resulting from the presence of an unseen companion. The rather short period of 84 days places the companion in an orbit similar to that of Mercury around the Sun, whereas the rather low velocity amplitude of about 0.6 km s⁻¹ implies that the mass of the companion may be as low as 0.011 solar masses, or 11 Jupiter masses. This leads to the suggestion that the companion is probably a brown dwarf, and may even be a giant planet. However, because the inclination of the orbit to the line of sight is unknown, the mass of the companion may be considerably larger than this lower limit.

FIG. 2 The orbital solution for the combined data set. The continuous line is the orbital solution with the parameters of Table 1. The CfA velocities are denoted by crosses, the CORAVEL velocities by filled circles.

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A planetary system around the millisecond pulsar PSR1257 + 12

A. WOLSZCZAN* & D. A. FRAIL†

*National Astronomy and Ionosphere Center, Arecibo Observatory, Arecibo, Puerto Rico 00613, USA
†National Radio Astronomy Observatory, Socorro, New Mexico 87801, USA

MILLISECOND radio pulsars, which are old (~10⁹ yr), rapidly rotating neutron stars believed to be spun up by accretion of matter from their usually found in binary systems with other degenerate stars¹. Using the 305-m Arecibo radiotelescope to make precise timing measurements of the recently discovered 6.2-ms pulsar PSR1257 +12 (ref. 2), we demonstrate that, rather than being associated with a stellar object, the pulsar is near planet-sized bodies. The planets detected so far have masses of at least 2.8 M⊕ and 3.4 M⊕ where M⊕ is the mass of the Earth. Their respective distances are 0.47 AU and 0.36 AU, and they move in almost circular orbits with periods of 98.2 and 66.6 days. Observations indicate that at least one of these planets may be present in this system. The detection of a planetary system around a nearby (~500 pc), old neutron star, together with the recent report on to the pulsar PSR1829–10 (ref. 3) raises the tantalizing possibility that a non-negligible fraction of neutron stars observable as radio pulsars n-like bodies.
Discovery of the „first“

A Jupiter-mass companion to a solar-type star

Michel Mayor & Didier Queloz
Geneva Observatory, 51 Chemin des Maillettes, CH-1290 Sauverny, Switzerland

The presence of a Jupiter-mass companion to the star 51 Pegasi is inferred from observations of periodic variations in the star’s radial velocity. The companion lies only about eight million kilometres from the star, which would be well inside the orbit of Mercury in our Solar System. This object might be a gas-giant planet that has migrated to this location through orbital evolution, or from the radiative stripping of a brown dwarf.
The solar system
Detection techniques

1. Imaging
2. Transit
3. Microlensing
4. Radial Velocities
5. Timing
Stars are a billion times brighter...
...than their planets.
Star/Planet contrast assuming pure blackbodies (no reflexion)
approx. Sun / Jupiter

Important: reflected light
First “Star + Planet” images

M = 0.025 M\(_{\text{Sun}}\)

M = 5 M\(_{\text{Jupiter}}\)

778 mas
55 AU at 70 pc

M = 0.7 M\(_{\text{Sun}}\)

M = 21 M\(_{\text{Jupiter}}\)

The Sub-Stellar Companion to GQ Lupi
(NACO/VLT)

NACO Image of the Brown Dwarf Object 2M1207 and GF

ESO PR Photo 26a/04 (10 September 2004)
First “direct” images of extrasolar planets
First “direct” images of extrasolar planets

Marois et al., 2008
First “direct” images of extrasolar planets

Lagrange et al., 2008
First “direct” images of extrasolar planets

Thalmann et al., 2009
Planets detected with the imaging technique
Planets detected with the imaging technique
Transits

Light Curve of a Star During Planetary Transit
Transits

HD209458 Transit

$P=3.524$ days
$a=0.046$, $e=0.02$
$M_{\text{ini}}=0.63$ Jupiter Masses

CoRoT Exo-1b

Normalized Flux
Kepler Field of View
Planets detected by transit
Planets detected by transit
Microlensing
Discovery of a Jupiter/Saturn Analog with Gravitational Microlensing


Searches for exoplanets have uncovered an astonishing diversity of planetary systems, yet the frequency of solar system analogs remains unknown. The gravitational microlensing planet search method is potentially sensitive to multiple-planet systems containing analogs of all the solar system planets except Mercury. We report the detection of a multiple-planet system with microlensing. We identify two planets with masses of ~0.71 and ~0.27 times the mass of Jupiter and orbital separations of ~2.3 and ~4.1 astronomical units orbiting a primary star of mass ~0.50 solar mass at a distance of ~1.5 kiloparsecs. This system resembles a scaled version of our solar system in that the mass ratio, separation ratio, and equilibrium temperatures of the planets are similar to those of Jupiter and Saturn. These planets could not have been detected with other techniques; their discovery from only six confirmed microlensing planet detections suggests that solar system analogs may be common.
Planets detected by micro-lensing

[Graphs showing the relationship between star mass and planet mass versus distance in AU.]
Planets detected by micro-lensing
Radial velocities
single spectrum
Doppler shift $v_{\text{rad}} = 10 \, \text{km/s}$
Doppler shift \( v_{\text{rad}} = 1 \text{ km/s} \)
Doppler shift $v_{rad}=1$ km/s
Precision today: ~1 m/s

< 1/1000 pixel (!)
Planets detected using radial velocities
Planets detected using radial velocities
Transit timing
Planets detected with transit timing
Planets detected with transit timing
Habitability
Habitability
The case for M stars
Mass-Radius relation
Atmospheres of Exoplanets

Primary Eclipse
Measure size of planet
See star’s radiation transmitted through the planet atmosphere

Secondary Eclipse
See planet thermal radiation disappear and reappear

Learn about atmospheric circulation from thermal phase curves

Figure by S. Seager
Spectroscopy Candidates

HD 189733b
P = 2.2d

HD 209458b
P = 3.5d

Imaging planets
(no transits)